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FINAL REPORT

TRANSFER OF A *PYEMOTES* EGG PARASITE PHORETIC ON WESTERN PINE BARK BEETLES TO THE SOUTHERN PINE BEETLE

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TRANSFER OF A *PYEMOTES*[1] EGG PARASITE PHORETIC ON WESTERN PINE BARK BEETLES TO THE SOUTHERN PINE BEETLE[2]

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ABSTRACT

Pyemotes giganticus has the widest phoretic latitude of any known *Pyemotes*, probably riding all scolytids and at least one tenebrionid beetle associate. The female heteromorph is not phoretic. The feeding latitude is narrow; the mite is known to feed only on scolytid eggs, and then reluctantly. Parasitism of a natural host, *Pseudohylesinus nebulosus*, is very low probably far less than one percent. Physogastric phoretomorphs gave birth to males, phoretomorphs, and female heteromorphs. Adults were born head first and the males did not assist in births.

Key Words: *Pyemotes giganticus*, Acarina, Pyemotidae, phoretomorph, phoretic, *Pseudohylesinus nebulosus*, *Dendroctonus frontalis*, Coleoptera, Scolytidae.

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[1] *Pyemotes giganticus* Cross, Moser, and Rack 1981 (Acarina:Pyemotidae).

[2] *Dendroctonus frontalis* Zimmerman 1868 (Coleoptera:Scolytidae).

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INTRODUCTION

Of the native mite species phoretic on *Dendroctonus frontalis* Zimmerman 1868, the southern pine beetle (SPB), several are predators of SPB immature stages, but none are parasitic (Moser 1976). Perhaps this contributes to the beetle's propensity for periodic population explosions. The three other primary competitors for the pine phloem food source (*Ips* spp.), rarely if ever, become epidemic perhaps because all host at least one mite parasite. Since no effective native mite parasites exist, one productive approach to the biological control of *D. frontalis* involves the search for extralimital mite parasites. But any mite species selected for introduction must also ride adult beetles during dispersal flights, since once introduced, phoresy is essential for the mite's continued survival. Although several mites have been documented as effective brood parasites of *D. frontalis* (Moser 1975, Moser *et al.* 1978), none would ride the beetle adults.

Pyemotes giganticus Cross, Moser, and Rack 1981 was first collected in 1966 by D. N. Kinn [4/] from adults of 16 bark beetle species of diverse genera taken from 10 species of conifers in California, Oregon, and Washington (Cross *et al.* 1981). Although the mite appeared to be confined to the western United States, its extremely wide phoretic host range raised the possibility that it might attack and ride any scolytid from coniferous trees, including the southern pine beetle.

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Morphologically, phoretomorphs and males of *P. giganticus* are practically indistinguishable from those of *Pyemotes dimorphus* Cross and Moser 1975, (Cross *et al.* 1981), but *P. giganticus* differs from all other *Pyemotes* by the presence of a giant female heteromorph. Phoretomorphs are common, but no normal forms are known.

This report documents the discovery of the first extralimital *Pyemotes* that rides SPB adults, and which attacks SPB eggs under experimental conditions.

METHODS AND MATERIALS

To check if *Pyemotes giganticus* overwinters in the phoretic state, 1000 overwintering *Pseudohylesinus nebulosus* (LeConte 1859) caught in light traps during March 1978 at Otis, Oregon, were shipped to Pineville, Louisiana, and scanned for phoretic mites.

A total of 198 bolts of Douglas-fir, *Pseudotsuga menziesii* (Mirbell 1825) Franco 1950 collected in the field at Otis, Oregon were received during the spring and summer of 1977, 1978, and 1979. The bolts contained galleries and brood of *P. nebulosus*. One half of the 1977 and 1978 bolts were dissected and the bark beetle galleries searched for females of *P. giganticus*, which were used to study the mites' biology and phoretic behavior. The other bolts were held in rearing cans and phoretic mites were collected from emerging parent and brood adults. Eight bolts received in May and June 1979 were all dissected and checked for the number of successful *P. nebulosus* galleries, beetle life stages, and for numbers and species of mites seen in the galleries. The number of *P. giganticus* attacking beetle eggs was also recorded.

To determine if *P. giganticus* phoretic on parent adults of *P. nebulosus* would reattach to *P. nebulosus* brood adults as well as adults of Central Louisiana bark beetles, phoretomorphs were exposed to adults of the pine bark beetles, *Dendroctonus frontalis, Ips avulsus* (Eichhoff 1868), *Ips calligraphus* (Germar 1824), *Ips grandicollis* (Eichhoff 1867), *Pityophthorus annectans* LeConte 1878, and a cedar bark beetle, *Phleosinus canadensis* Swaine 1917. Phoretomorphs were gently teased from recently emerged parent adults of *P. nebulosus* and placed individually in plaster of Paris chambers of the type described by Moser (1975). Here they were exposed to 20 individuals each of both sexes of parent and brood adults of the SPB, the 3 *Ips* species, and to 10 unsexed individuals each of *P. annectans, P. canadensis and to P. nebulosus* brood adults.

To see if *P. giganticus*' phoretic latitude might extend to beetle associates unrelated to scolytids, three bolts of western hemlock, *Tsuga heterophylla* (Rafinesque 1832), Sargent 1898 were received during the spring of 1976 with galleries of *Pseudohylesinus tsugae* Swaine 1917. Several adults of *Corticeus subopacus* (Wallis 1933), a tenebrionid associate, emerged from the bolts and were scanned for phoretic *P. giganticus*.

The ability of recently born and fertilized *P. giganticus* phoretomorph and heteromorph females to bond phoretically with SPB, the 3 *Ips* species, and brood adults of *P. nebulosus* was checked by placing 5 unsexed bark beetles of each species in plaster of Paris cells with physogastric phoretomorphs giving birth to both phoretomorphs and female heteromorphs. Observations terminated 2 days after the last mite was born.

Brood production of physogastric females was tallied by removing physogastric females from galleries, placing them in plaster of Paris cells, and recording numbers of males, phoretomorphs and female heteromorphs, and their order of birth.

The attractiveness of bark beetle brood as food was determined by separately placing eggs, early larvae, and pupae of SPB, the 3 species of *Ips* and *P. nebulosus* in the plaster of Paris cells with recently born and mated phoretomorphs and female heteromorphs of *P. giganticus*. Beetle brood were observed daily for evidence that mites had attacked and/or fed on them. Phoretomorph tests were replicated 10 times each, and female heteromorphs 5 times. To see if phoresy increased attack aggressiveness the latter tests were replicated 20 times with phoretomorphs removed from emerged *P. nebulosus* parent adults in plaster of Paris cells with brood of the above 5 species of bark beetles.

To simulate field conditions phoretomorphs were removed from parent adults of *P. nebulosus* and allowed to reattach on brood adults of SPB, the 3 species of *Ips* and *P. nebulosus*. The beetles with phoretic mites were then allowed to bore into and form egg galleries in phloem sandwiches of the type described by Bushing (1967). These mites were observed under the plexiglass at least once daily to see if they attacked beetle brood. Emerging brood adults were checked for any phoretic mites

Using *Pinus taeda* L. 1753 as a phloem source, three pairs of *D. frontalis* were allowed to penetrate and form galleries in each of 5 sandwiches; the female of each of the 15 pairs carried a single phoretomorph. The same procedure was repeated for each of the 3 *Ips* species. In addition, another sandwich was colonized with a single pair of *D. frontalis*, the female of which carried 5 phoretomorphs. Still another pair of parent adults of *P. nebulosus*, both of which carried 3 phoretomorphs made galleries in a sandwich composed of Douglas-fir phloem. The behavior of the mites were observed daily until the parent adults emerged, after which the sandwiches were opened and inspected to see if any beetle brood had been attacked, and for *Pyemotes* reproduction.

Brood adults emerging from 3 loblolly pine bolts were checked for phoretic *Pyemotes*. The bolts were 20 cm diameter and 1.3 m long and had been previously inoculated in the laboratory with pairs of *D. frontalis*, the females of which carried phoretomorphs. Two bolts were stocked with 14 pairs, each female carrying a single phoretomorph. The third bolt had 9 pairs, each female carrying 3 phoretomorphs. Emerging beetles were checked for mites, and after emergence, the bolts were dissected and checked for evidence that beetle brood had been attacked, and for *Pyemote* reproduction.

RESULTS AND DISCUSSION

Only 44 of the 1000 overwintering *Pseudohylesinus nebulosus* possessed phoretic mites, and only 2 of these had *Pyemotes giganticus*. Thirty-eight beetles possessed a single mite, 3 had 3 mites, 2 had 3 mites, and one carried 4 mites. Four species of mites were seen. Most common were the 38 *Calvolia* sp. hypopae, followed by 2 males and 20 females of *Choriarchus reginus* Kinn 1966, and 2 females each of *Pyemotes giganticus* and *Microdispodides* n.sp. *C. reginus* and *Microdispoidides* n.sp. were phoretic under the elytra, whereas *P. giganticus* were attached to the setae in the vicinity of the coxae, and the *Calvolia* sp. were generally distributed over the body.

About 10 percent of several hundred parent adults reared from the Douglas-fir bolts had as many as 9, but usually 2-3 phoretomorphs of *P. giganticus* attached to the setae at the bases of the coxae (Figure 1), but rarely on the legs. But curiously, no phoretomorphs were seen on any of the several thousand brood adults reared from the bolts. This may explain their low incidence on the overwintering *P. nebulosus*. The ratio of brood adults to parent adults in the overwintering beetles is not known, but they probably are virtually all brood adults with only a small percentage (if any) of parent adults (Julius Rudinsky, personal communication).

Eight bolts with *P. nebulosus* attacks were received in 1979, and all were disssected to determine the incidence of parasitism. Three bolts received in May had 37, 56, and 64 egg galleries containing eggs. *P. giganticus* was absent.

Five bolts received in June contained 15, 15, 17, 20, and 27 egg galleries respectively. *P. giganticus* were found in only two of the bolts. In the bolt with 27 attacks, 3 phoretomorphs were seen in one of the egg galleries with 30 egg niches, but no evidence of the physogastric mother was found; all 30 eggs had hatched into first-instar larvae. In the bolt with 17 attacks, 3 galleries contained *P. giganticus*. In the first egg gallery containing 12 unhatched eggs, a dead, one-third swollen phoretomorph was found in an egg niche along with the beetle egg remains. The second gallery contained 18 eggs, 12 of which had hatched to first-instar larvae. One live, physogastric phoretomorph mother with 16 daughter phoretomorphs clustered around her was seen in one of the egg niches. The third egg gallery contained 30 first-instar larvae, each in larval galleries radiating away from the egg gallery. Three phoretomorphs were seen crawling in the egg gallery, but no physogastric mother was found.

It appears, then, that the mite attacks eggs and that its impact was negligible under field conditions, the percentage of parasitism being less that one percent.

The phoretomorphs teased from parent adults of *P. nebulosus* all reattached within 1 min to the brood adults of *P. nebulosus*, as well as to both sexes of parent and brood adults of the SPB, the 3 *Ips* species, and to the adults of *P. annectans* and *P. canadensis*. This confirms previous unpublished records by Kinn that the mite has an unusually broad phoretic spectrum. The fact that the mite is phoretically aggressive toward *P. nebulosus* brood adults, at least in the laboratory, is evidence that the mite's absence on flying brood adults is at least not due to lack of phoretic attraction by brood adults. It is of interest to know that phoretomorphs of *P. giganticus* will bond phoretically to the cedar bark beetle, *P. canadensis*, because this beetle is host to *Pyemotes dimorphus* a species so closely related to *P. giganticus* that the phoretomorphs cannot be separated morphologically.

One specimen of the *Corticeus subopacus* had 3 phoretomorphs of *P. giganticus* attached when it emerged from the bolt infested with *P. tsugae* (Figure 2). This finding expands the phoretic latitude of *P. giganticus* to beetles other than scolytids, and is the first record of a *Pyemotes* phoretic on a nonscolytid.

Behaviorally, *P. giganticus* differs from all other species of *Pyemotes*, because all are either nonphoretic, or are relatively host specific, riding at most on a single genus of scolytids. Except for *P. giganticus*, no *Pyemotes* is phoretic on the southern pine beetle, although most readily attack laboratory cultures of brood.

The recently born and fertilized phoretomorphs were attracted to and mounted bark beetles as aggressively as those teased from the parent adults of *P. nebulosus*. Only one newly born heteromorph female was available for testing, but it refused to ride adults of SPB or the 3 *Ips* species. This is not surprising, since the leg 1 claw of the heteromorph is not shaped for grasping setae.

Because physogastric females were rare and fragile, only two were found intact. The first physogastric phoretomorph, retrieved slightly injured, gave birth to 12 phoretomorphs, but no males or female heteromorphs. The second phoretomorph gave birth to a total of 2 males, 5 heteromorph females, and 20 phoretomorph females, all born head first. A male was born first, followed by the female heteromorphs, the second male, and finally the phoretomorphs. Males did not assist in the birth of the females as is common with many species of *Pyemotes* (Moser *et al.* 1971). Rather they waited until the female was free of the birth canal and then mated with her.

Neither the recently born and mated phoretomorph nor heteromorph females attacked eggs, early larvae, or pupae of the 5 bark beetle species in the plaster chambers. Phoretomorphs removed from emerged parent adults likewise refused to attack.

One mite did attack a SPB egg under simulated field conditions. Of the 71 phoretomorphs introduced into the phloem sandwiches on 63 adults of the 5 bark beetle species, the only successful attack was one of the 5 attached to the single female *D. frontalis*. By the 6th day when the sandwich was opened, one phoretomorph had attacked and deflated an egg, and appeared fully swollen. In the gallery, another mite was still attached to the beetle, and another was seen crawling; the other 2 could not be located. Parent adults were allowed to emerge from the other 61 galleries of the 5 scolytid species tested before the sandwiches were opened and searched for mites. In each case no phoretomorphs were seen on the parent adults, no mites could be located in the galleries, nor was there any evidence that any eggs had been attacked by the mites. Mites were seen through the glass still attached to female beetles as they were constructing egg galleries (Figure 3).

From the bolts inoculated with *D. frontalis* and attached phoretomorphs, 156 and 430 parent and brood adult beetles emerged from 2 bolts, each stocked with 14 pairs of beetles. Only 20 beetles emerged from the third bolt stocked with 9 pairs. No mites were attached to any of the emerged beetles. Upon dissection of the bolts, no mites were found in the galleries, nor was there any evidence that they had attacked the immature stages of the beetle.

CONCLUSIONS

These findings do not support the release of *Pyemotes giganticus* into the field as a biological control agent of SPB. Although phoretic data show that the mite readily rides SPB and other southern pine bark beetles, the reluctance of *P. giganticus* to attack immature stages of any bark beetle, both in the laboratory and in its native habitat, argues against the survival of the mite if introduced.

ACKNOWLEDGEMENTS

J. A. Rudinsky and L. C. Ryker collected and sent the *Pseudohylesinus* material. Their comments on the biology of the beetle aided in the course of the research and in writing of the manuscript. C. A. Triplehorn identified *Corticeus subopacus*. E. A. Cross, D. N., Kinn, G. Rack, and J. A. Rudinsky reviewed the manuscript.

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FIGURE CAPTIONS

Figure 1. *Pseudohylesinus nebulosus* adult with phoretomorph (arrow) of *Pyemotes giganticus* attached in the vicinity of the base of coxae 1.

Figure 2. *Corticeus subopacus* adult with phoretomorph (arrow) of *Pyemotes giganticus* attached between bases of coxa 1 and coxa 2.

Figure 3. Southern pine beetle female seen through glass boring egg gallery in phloem sandwich. Phoretomorph of *Pyemotes giganticus* (arrow) is attached to abdomen just behind base of coxa 3.

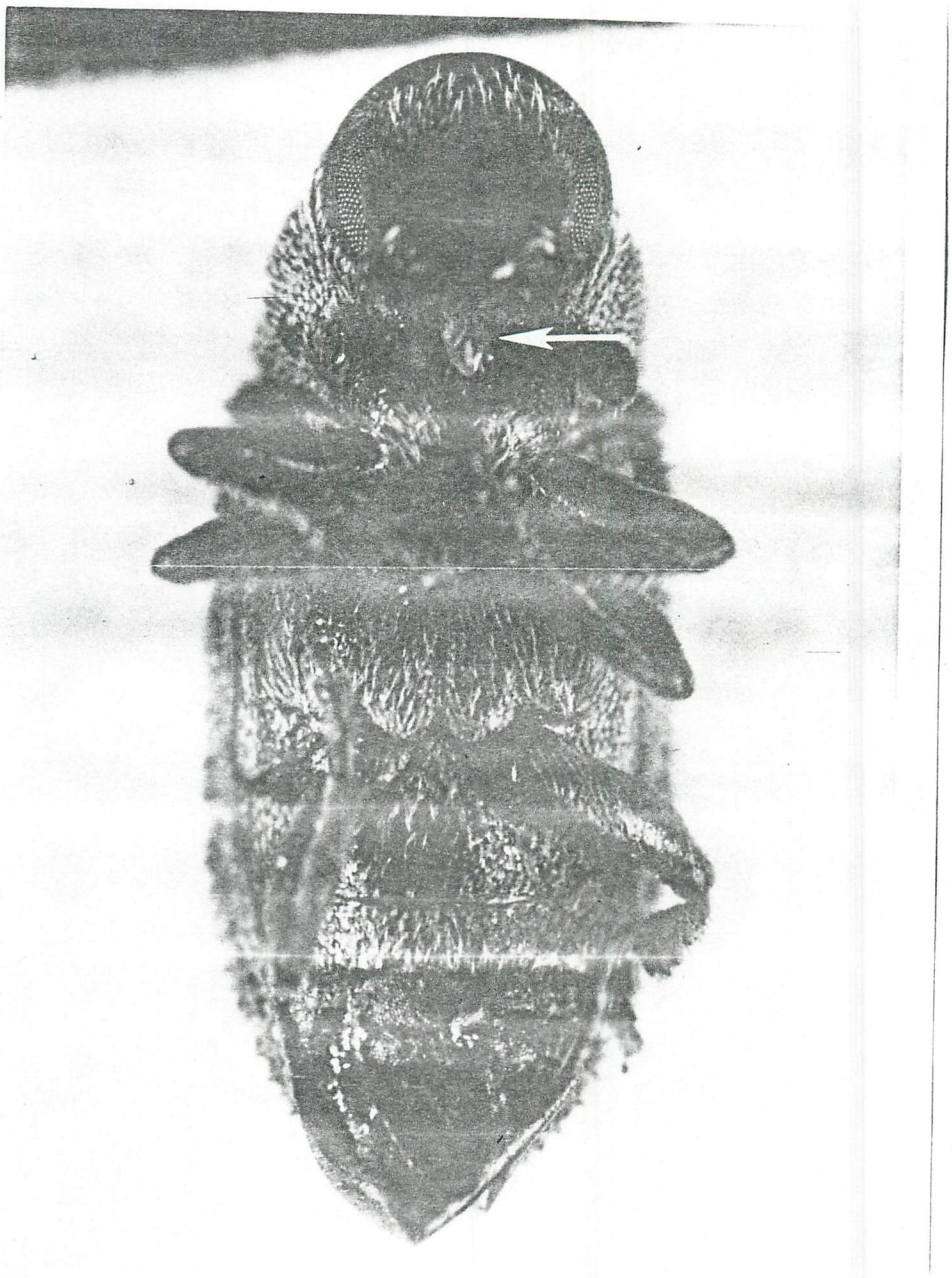

Figure 1.

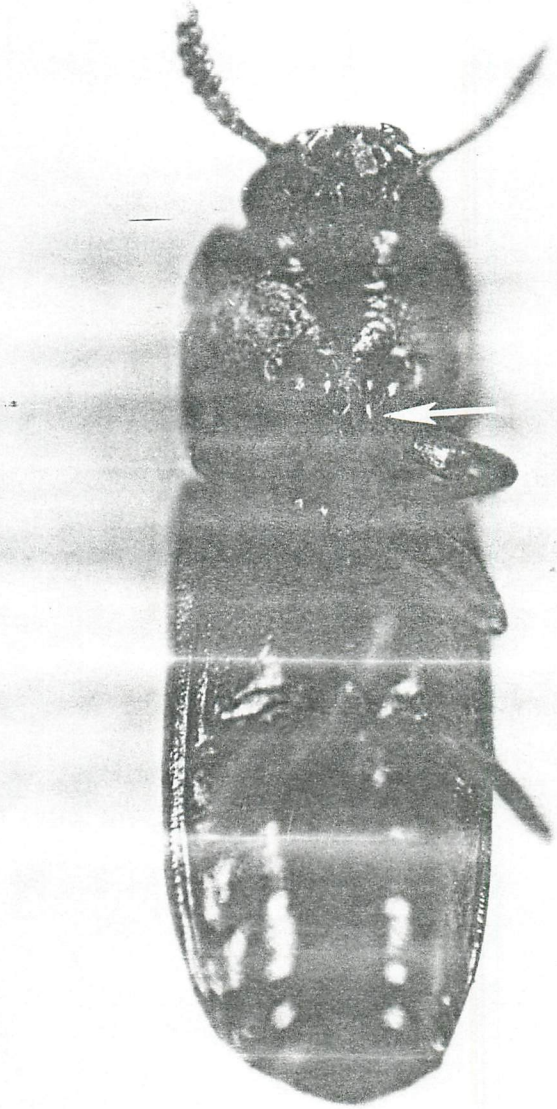

Figure 2.

Figure 3.